

UNITED STATES PATENT APPLICATION
FOR
FABRICATION OF MICROELECTRONIC DEVICES

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FABRICATION OF MICROELECTRONIC DEVICES

FIELD

[0001] An embodiment of the invention relates to microelectronic devices in general, and more specifically to fabrication of microelectronic devices to affect expansion characteristics.

BACKGROUND

[0002] In the manufacture of microelectronic devices, a die may be created and affixed to a package to form a device. However, the die and the other parts of the package may have differing characteristics. One important difference relates to the coefficient of thermal expansion (CTE), which is a value that expresses how a material expands or contracts as temperatures change.

[0003] If a die has a different CTE than the package and therefore expands at a different rate than the package, there is a risk of mechanical failure, including mechanical failure of interconnects between the die and the package. Reliable connection of a die to a package is difficult, and CTE mismatch between the die and package can complicate fabrication of microelectronic devices. With the use of low K (dielectric constant) ILD (inter-layer dielectric) materials on die in device construction, the risk of failure for microelectronic devices may increase.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The invention may be best understood by referring to the following description and accompanying drawings that are used to illustrate embodiments of the invention. In the drawings:

[0005] **Figure 1** illustrates an embodiment of a package;

[0006] **Figure 2** illustrates an embodiment of a die placed in a package;

[0007] **Figure 3** illustrates an embodiment of a die placed in a package and covered by an integrated heat spreader;

[0008] **Figure 4** is a flow chart illustrating an embodiment of the invention;
and

[0009] **Figure 5** is a schematic representation of an embodiment of a computer.

DETAILED DESCRIPTION

[0010] A method and apparatus are described for microelectronic package fabrication.

Terminology

[0011] Before describing an exemplary environment in which various embodiments of the present invention may be implemented, some terms that will be used throughout this application will briefly be defined:

[0012] As used herein, “die” or means an unpackaged microelectronic device.

[0013] As used herein, “package” means a component to wholly or partially contain a die. The package generally provides electrical connections for a die.

[0014] As used herein, “microelectronic device” means a device including a die in a package.

[0015] As used herein, “CTE” or “coefficient of thermal expansion” means a measure of contraction or expansion of a material or device as a function of temperature change.

[0016] According to an embodiment of the invention, a microelectronic device that comprises a package and a die is fabricated such that the package exerts forces on the die to cause it to expand and contract with the package. The device is constructed such that the apparent CTE of the die more closely matches to the CTE of the package.

[0017] According to an embodiment of the invention, a die is bonded or coupled with a stiffener or other plate or surface, referred to herein as a “plate”. The plate may be of any shape that allows expansion and contraction with temperature changes. The plate expands and contracts with temperature, and thus places physical

stress on the die that is attached to it. The use of the plate modifies the apparent or effective CTE of the die, i.e., modifying the rate of change in size of the die as a function of temperature. According to an embodiment of the invention, the apparent CTE of a die is modified to more closely match the CTE of a package for the die.

[0018] The coupling or bonding of a die with a plate or stiffener varies according to the particular embodiment. The die may be attached by any method that allows the plate to impart physical force to the die as the temperature of the plate changes and the plate expands or contracts.

[0019] In one embodiment of the invention, a die is attached, bonded, or otherwise coupled at the edges of the die with a surrounding plate. In this embodiment, the plate includes a hole or cavity constructed to allow insertion of the die. The die may be inserted into the plate and one or more edges of the die may be coupled with the plate. In one example, the plate includes a hole that is shaped similarly to the shape of the die. The die is inserted into this hole and one or more edges of the die are coupled with the plate. According to an embodiment of the invention, the die is placed into the plate at a relatively higher temperature. When the plate and die cool, the plate may contract around the die, ensuring a tight fit and good mechanical coupling between the die and the plate.

[0020] In another embodiment of the invention, a side of a die is coupled with a plate. The side attached to the die may be an inactive side of the die, a side that does not include electronic connections or traces. The plate may act as an integrated heat spreader. According to the embodiment, one side of the plate is attached, bonded, or otherwise coupled with a side of the die. The coupling of the plate and the die allows for physical attachment of all or a part of one side of the die with the plate.

[0021] The method of coupling a die with a plate will vary with the embodiment of the invention. In one example, an edge or a side of a die is bonded to the plate using a bonding material that provides a strong seal as the plate and die expand and contract with temperature. The bonding material may include, but is not limited to, a stiff solder material or adhesive. Other methods may also be used to couple the die with the plate.

[0022] According to an embodiment of the invention, a plate is constructed of a material that modifies the apparent CTE of a die. The apparent CTE of a die may be modified to more closely match the CTE of the package. The material used in constructing the plate will vary according the embodiment. According to one embodiment of the invention, the plate comprises copper or a copper alloy, but other materials may be utilized in conjunction with an embodiment of the invention. The plate coupled with the package may be of any shape that allows expansion and contraction with temperature changes. The plate expands and contracts with temperature, and thus places physical stress on the package.

[0023] According to an embodiment of the invention, a die that is coupled with a plate is coupled with the package. In addition to any other coupling, the die is coupled to provide electrical connection with the package, which then provides connection with electrical contacts. In one example, a package may comprise a plurality of solder bumps or similar contacts, and the die is coupled with the solder bumps or contacts.

[0024] According to an embodiment of the invention, a package may include a second plate. In one example, the plate is coupled with the package on a different side of the package than the side used for coupling the die with the package. The plate may be

chosen to affect the CTE of the package. In one embodiment, the CTE of the plate coupled with the package is similar to the CTE of the plate coupled with the die. In a particular example, the plate coupled with the package is constructed of the same material as the plate coupled with the die.

[0025] The method of coupling a package with a plate will vary with the embodiment of the invention. In one example, a side of a package is bonded to the plate using a bonding material that provides a strong seal as the plate and die expand and contract with temperature. The bonding material may include, but is not limited to, a stiff solder material or adhesive. Other methods may also be used to couple the package with the plate.

[0026] The figures presented here illustrate a particular package structure for use with a die. However, embodiments of the invention are not limited to this particular package structure. Embodiments of the invention are usable in any environment in which a die is utilized with a package to form a microelectronic device.

[0027] **Figure 1** is an illustration of a package that may be utilized in conjunction with an embodiment of the invention. The package **100** comprises a package body **105**, through which there is a plurality of vias **110**. At a first end, the vias connect to solder bumps **120**, which may comprise Sn/Ag (tin/silver) solder, to provide a connection to a die. The vias **110** fan out to connect to conductors **115**, which are spread more widely than the solder bumps **120** to allow a more usable pitch for connections to a board, mounting device, or other connection. The package **100** may include one or more plates for use in modifying CTE factors to more closely match the apparent CTE of the die with the CTE of the package. The plates may be referred to as “stiffeners”. In one

embodiment, a first plate **125** may surround the solder bumps **120** around an area to be used for installation of a die into the package **100**. A second plate **130** may be coupled on the opposite side of the package **100**. The second plate is shown attached to the package **100** by an adhesive **135**.

[0028] **Figure 2** is an illustration of a package and die according to an embodiment of the invention. The package **200** comprises a package body **205**, through which there is a plurality of vias **210**. At a first end, the vias connect to solder bumps **220** to provide a connection to a die **240**. The vias **210** fan out to connect to conductors **215**. A die **240** is connected to the solder bumps. In this illustration, a plate is present on either side of the package. The first plate **225** surrounds the die **240**. For example, the first plate **225** may comprise a hole for the placement of a die. The first plate **225** is coupled with the die **240** at one or more edges of the die by material, such as a stiff solder, that provides a secure physical connection to the first plate **225**. In one embodiment, the die **240** is constructed to be more thin than usual in order to allow for construction in the device and to allow for thermal expansion of the die. For example, the die **240** may be a thickness of approximately 250 μ m, as opposed to a standard thickness of approximately 700 μ m. A second plate **230** is coupled with the package **200** on the opposite side. The second plate **230** is shown attached to the package **200** by an adhesive **235**, although other methods of coupling the second plate to the package may be used. In one embodiment, the second plate **330** is approximately 150 μ m thick.

[0029] As illustrated by Figure 2, the first plate **225** modifies the apparent CTE of the die **235** to more closely match the CTE of the package **200**. As temperature increase and the first plate **235** expands, the die **235** is forced to expand by forces pulling

on the die **235** at the points of attachment between the die **235** and the first plate **225** on edges of the die **235**. The package is coupled with the second plate **230** by the adhesive **230** and the connection to the second plate **230** modifies the CTE of the package. With the effect of the first plate **225** and the second plate **230**, the apparent CTE of the die **235** may be designed to more closely match the CTE of the package **200**, which may reduce the potential for mechanical failure of connections and other issues related to mismatch of CTE for a microelectronic device.

[0030] **Figure 3** is an illustration of a package and die according to an embodiment of the invention. The package **300** comprises a package body **305**, through which there is a plurality of vias **310**. At a first end, the vias connect to solder bumps **320** to provide a connection to a die. The vias **310** fan out to connect to conductors **315**. A die **340** is connected to the solder bumps. The package **300** comprises a plate on either side of the package. A first plate **325** is coupled with the die **340**. The first plate **325** is coupled with one side of the die (the inactive side of the die) by a material providing a strong connection to the die, such as a stiff solder. The first plate **325** acts as an integrated heat spreader for the device. In one embodiment, the die **340** is constructed to be more thin than usual in order to allow for construction of the microelectronic device and to allow for thermal expansion of the die **340**. For example, the die **340** may be a thickness of approximately 50µm, as opposed to a standard thickness of approximately 700µm. In this embodiment, the first plate **325** can be thicker than the die **340**. A second plate **330** may be attached to the package on the opposite side. The second plate **330** is shown attached to the package **300** by an adhesive **335**, although other methods of coupling the plate to the package **300** may be used. The thickness of the second plate **330**

will vary according to the embodiment. In one embodiment, the second plate **330** is approximately 150 μ m thick.

[0031] As illustrated by Figure 3, the first plate **325** modifies the apparent CTE of the die **335** to more closely match the CTE of the package **300**. As temperature increase and the first plate **335** expands, the die **335** is forced to expand by forces pulling on the die **335** at the points of attachment between the die **335** and the first plate **325** on the inactive side of the die **335**.

[0032] In Figures 2 and 3, a first plate and a second plate are constructed of materials chosen to match the apparent CTE of a die to the CTE of a package. In one embodiment, the first plate and the second plate are constructed of the same material. The material used to construct the first plate and the second plate will vary according to the embodiment, including but not limited to copper.

[0033] **Figure 4** is a flowchart illustrating an embodiment of the invention. The order of the tasks presented in Figure 4 may vary according to the embodiment and the fabrication process used. According to the embodiment, a package body is constructed **405**. The construction of the package body may include coupling a first plate with the package body **410**. A die is constructed **415**. The die is coupled with a second plate **420**. In one example, the second plate is coupled to the edges of the die with an appropriate material, such as with a stiff solder. In another example, the second plate is coupled with one side of the die. The first plate and the second plate are constructed of materials that will cause the apparent CTE of the die to more closely match the CTE of the package. In one embodiment, the first plate and the second plate are constructed of copper.

Alternative Embodiments

[0034] Techniques described here may be used in many different environments. **Figure 5** is block diagram of an exemplary computer that can be used in conjunction with an embodiment of the invention. The computer includes one or more microelectronic devices that comprise an embodiment of the invention. Under an embodiment of the invention, a computer **500** comprises a first bus **505** or other communication means for communicating information, and a processing means such as one or more processors **510** (shown as **511**, **512** and continuing through **513**) coupled with the bus **505** for processing information. One or more of the processors may comprise an embodiment of the invention.

[0035] The computer **500** further comprises a random access memory (RAM) or other dynamic storage device as a main memory **515** for storing information and instructions to be executed by the processors **510**. Main memory **515** also may be used for storing temporary variables or other intermediate information during execution of instructions by the processors **510**. The computer **500** also may comprise a read only memory (ROM) **520** and/or other static storage device for storing static information and instructions for the processor **510**. One or more memory devices may comprise an embodiment of the invention.

[0036] A data storage device **525** may also be coupled to the first bus **505** of the computer **500** for storing information and instructions. The data storage device **525** may include a magnetic disk or optical disc and its corresponding drive, flash memory or other nonvolatile memory, or other memory device. Such elements may be combined

together or may be separate components, and utilize parts of other elements of the computer **500**.

[0037] The computer **500** may also be coupled via the bus **505** to a display device **530**, such as a liquid crystal display (LCD) or other display technology, for displaying information to an end user. In some environments, the display device may be a touch-screen that is also utilized as at least a part of an input device. In some environments, display device **530** may be or may include an auditory device, such as a speaker for providing auditory information. An input device **540** may be coupled to the bus **505** for communicating information and/or command selections to the processor **510**. In various implementations, input device **540** may be a keyboard, a keypad, a touch-screen and stylus, a voice-activated system, or other input device, or combinations of such devices. Another type of user input device that may be included is a cursor control device **545**, such as a mouse, a trackball, or cursor direction keys for communicating direction information and command selections to processor **510** and for controlling cursor movement on display device **530**.

[0038] A communication device **550** may also be coupled to the bus **505**. Depending upon the particular implementation, the communication device **550** may include a transceiver, a wireless modem, a network interface card, or other interface device. The computer **500** may be linked to a network or to other devices using the communication device **550**, which may include links to the Internet, a local area network, or another environment.

General Matters

[0039] In the description above, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art that the present invention may be practiced without some of these specific details. In other instances, well-known structures and devices are shown in block diagram form.

[0040] The present invention includes various steps. The steps of the present invention may be performed by hardware components or may be embodied in machine-executable instructions, which may be used to cause a general-purpose or special-purpose processor or logic circuits programmed with the instructions to perform the steps. Alternatively, the steps may be performed by a combination of hardware and software.

[0041] Portions of the present invention may be provided as a computer program product, which may include a machine-readable medium having stored thereon instructions, which may be used to program a computer (or other electronic devices) to perform a process according to the present invention. The machine-readable medium may include, but is not limited to, floppy diskettes, optical disks, CD-ROMs, and magneto-optical disks, ROMs, RAMs, EPROMs, EEPROMs, magnet or optical cards, flash memory, or other type of media / machine-readable medium suitable for storing electronic instructions. Moreover, the present invention may also be downloaded as a computer program product, wherein the program may be transferred from a remote computer to a requesting computer by way of data signals embodied in a carrier wave or

other propagation medium via a communication link (e.g., a modem or network connection).

[0042] Many of the methods are described in their most basic form, but steps can be added to or deleted from any of the methods and information can be added or subtracted from any of the described messages without departing from the basic scope of the present invention. It will be apparent to those skilled in the art that many further modifications and adaptations can be made. The particular embodiments are not provided to limit the invention but to illustrate it. The scope of the present invention is not to be determined by the specific examples provided above but only by the claims below.

[0043] It should also be appreciated that reference throughout this specification to “one embodiment” or “an embodiment” means that a particular feature may be included in the practice of the invention. Similarly, it should be appreciated that in the foregoing description of exemplary embodiments of the invention, various features of the invention are sometimes grouped together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of one or more of the various inventive aspects. This method of disclosure, however, is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the claims are hereby expressly incorporated into this description, with each claim standing on its own as a separate embodiment of this invention.